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### DUSTING WITH MONOHYDRATED COPPER SULPHATE AND LIME FOR CONTROL OF PECAN SCAB

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#### CONTENTS

	Page		Page
Introduction -----	1	Cost of dusting -----	7
Experiments at Thomasville, Ga. -----	2	Suggestions -----	7
Experiments at Albany, Ga. -----	4	Directions for using the copper and lime dust -----	8
Meteorological conditions affecting scab infection -----	6	Summary -----	8

#### INTRODUCTION

Pecan scab, already a limiting factor in pecan nut production, may become a menace to the new and growing pecan industry in southeastern United States. The fungus<sup>1</sup> causing the disease is becoming better established and more abundant each year in the older pecan-growing sections. During 1926 the disease caused a total loss in the untreated orchards of many localities of the crop from the varieties Schley, Delmas, Alley, Pabst, and Van Deman. The fungus seems to be adapting itself gradually to such varieties as Moneymaker, Stuart, and Frotscher—varieties which at one time were considered highly resistant or possibly immune. The commercial control of this disease, therefore, is a matter of great importance to pecan growers in the South.

The writers pointed out in a previous publication<sup>2</sup> that two to four applications of a standard strength (3-3-50) Bordeaux mixture, properly timed, when supplemented by orchard sanitation, would effectively control pecan scab. Owing to the disagreeable work in-

<sup>1</sup> This fungus has been described, probably incorrectly, as *Fusicladium effusum* Winter.

<sup>2</sup> DEMAREE, J. B., and COLE, J. R. COMMERCIAL CONTROL OF PECAN SCAB. U. S. Dept. Agr. Circ. 386, 8 p. 1926.

volved in spraying large pecan trees, the scarcity of suitable labor, and the cost of high-powered spray machinery, however, pecan growers have been reluctant to adopt this method of protecting their crops from destruction by the scab fungus.

There has been a widespread interest among pecan growers in the possibilities of controlling the disease by using a dust fungicide. To meet this situation the writers conducted extensive laboratory experiments during 1924 and 1925 to test the relative toxicity of dust fungicides of the various types to spores of the pecan scab fungus. The laboratory tests indicated that a mixture of monohydrated copper sulphate and lime dust largely prevented germination and was also quite toxic to the germ tubes of germinating spores. During the summer of 1926 orchard experiments were conducted to test the efficacy of monohydrated copper sulphate and lime dust under orchard conditions. Two tests were made in Georgia, one at Thomasville and the other near Albany. The purpose of this circular is to furnish pecan growers with the results of dusting experiments for 1926.

### EXPERIMENTS AT THOMASVILLE, GA.

The experiments at Thomasville, Ga., were conducted on 20-year-old trees of the Schley variety. The trees averaged 50 feet in height and 45 feet in spread of limbs, exceeding in dimensions the average pecan trees growing in orchards of the Southeast. During the winter preceding the experiments the shucks from the former year's crop of nuts were removed from the trees, and later the ground was plowed with a turning or moldboard plow. The trees had received protective and sanitary treatment for two summers prior to 1926. This treatment seemed to have reduced the disease inoculum in the orchard, as practically no leaf infection appeared during the entire summer of 1926 except on the trees receiving no application of the fungicide. These treatments undoubtedly influenced the results of the experimental work during 1926.

About 8 pounds of a 20-80 commercial mixture of monohydrated copper sulphate and lime dust, analyzing approximately 7 per cent metallic copper, was applied to each tree on May 12, June 11, July 9, and August 3. In order to insure a more uniform distribution of the dust it was applied from both sides of the tree rows. The applications were made between dawn and sunrise. Mornings were selected when the leaves and nuts were wet with either dew or rain.

The results obtained in these experiments were very satisfactory, as shown in Table 1. They were even more remarkable, however, when the type of dusting outfit used is taken into consideration. The machine used was an old-type duster designed to dust peach and apple trees; consequently its power and capacity were inadequate to dust properly the pecan trees selected. The mechanical weakness of the outfit was partly overcome by the use of a tower that placed the operator about 6 feet above the ground. The ordinary 4½-foot discharge pipe was replaced by one 10 feet long, which enabled the operator to do better work in the tops of the trees. The first application was made while the dusting fan was moving at the rate of only 1,100 revolutions a minute. Later applications were made with the fan at its maximum speed of about 2,400 revolutions a minute.



TABLE 1.—*Comparison of results obtained by dusting pecan trees with 20-80 monohydrated copper sulphate and lime mixture and by spraying with 3-3-50 Bordeaux mixture for control of pecan scab at Thomasville, Ga., 1926*

Character of treatment	Number of trees treated	Average quantity of nuts set per tree	Average loss of nuts per tree from causes other than scab <sup>1</sup>	Average loss of nuts per tree due to scab <sup>2</sup>	Average quantity of nuts harvested per tree
Dusted four times with monohydrated copper sulphate and lime dust.....	10	Pounds 72.76	Pounds 18.1	Pounds 2.16	Pounds 52.5
Sprayed three times with 3-3-50 Bordeaux mixture.....	2	95.8	23.3	0	72.5
Control (not dusted or sprayed).....	1	82.8	18	60	4.8

<sup>1</sup> Black pit, insect injuries, and high winds.

<sup>2</sup> Including unmarketable nuts and those which dropped prematurely.

The records of dusted nuts were taken from 10 trees treated alike. The weight of the crop of nuts harvested from these trees ranged from 32.5 to 80 pounds and averaged 52.5 pounds of nuts per tree. There was a heavy drop of nuts due to black pit, insect injuries, and to high winds during July and August. From 20 to 25 per cent of the total crop fell prematurely as a result of the action of those agencies. The nuts that dropped prematurely were gathered at frequent intervals during the season and counted. At the same time the probable cause of the drop was determined. The number of pounds of nuts that dropped was calculated on the basis that 60 nuts, tree run, weigh 1 pound. The quantity of nuts set per tree was computed by adding the estimated number of pounds lost to the total number of pounds harvested. These methods apply also to the records covered by Table 3. The husks of many of the dusted nuts became infected with the scab organism during a 36-hour infection period on August 28 and 29. Fortunately, however, these late infections caused only a small percentage of faulty nuts on those trees dusted or sprayed. No drop occurred as the result of scab, but a few pounds of faulty nuts were found within the centers of the trees and in the extreme topmost parts, presumably where the dust was not properly distributed.

Since Bordeaux mixture is considered the standard fungicide for preventing infection of pecan scab, the record of two trees sprayed three times with Bordeaux mixture is included in Table 1 for comparison with the dusting results.

Taking into consideration the nuts which had dropped prematurely, the control tree set a heavy crop of nuts, estimated at 82.8 pounds. Less than 5 pounds of the total nuts set were classified as marketable at harvest time. A loss of 60 pounds of nuts was due directly to scab, while a loss of 18 pounds was caused by other factors.

The method of grading the nuts shown in Table 2 is one approved by the National Pecan Growers Association for pecans of the general type and shape of the Schley variety. With the exception of the control tree, 25 pounds of nuts were used in obtaining the grading percentage. The grading was done by running the nuts through an improved power grader owned by the National Pecan Growers

Exchange, Albany, Ga. All nuts having a diameter of fifteen-sixteenths inch and over are considered as oversize. The No. 1 grade includes nuts with diameters of fourteen-sixteenths and thirteen-sixteenths inch; the No. 2 grade includes nuts with a diameter of about twelve-sixteenths inch; and the No. 3 grade includes those which pass through an eleven-sixteenths inch opening. A relatively large percentage of the dusted nuts were graded as oversize, while 94 per cent were classed as No. 1 grade and larger.

The classification data of the untreated nuts may seem from a casual examination somewhat misleading, but it must be remembered that these data were taken from less than 5 pounds of marketable nuts harvested from a tree which incurred a loss of 60 pounds as the result of scab.

TABLE 2.—Yield, cracking percentage, and grading percentage of nuts harvested from pecan trees included in the dusting experiments at Thomasville, Ga., 1926

Character of treatment	Number of trees treated	Count of nuts to the pound	Cracking percentage	Grading percentage			
				Over-size	No. 1	No. 2	No. 3
Dusted four times with monohydrated copper sulphate and lime dust.....	10	61	62	14	80	4	2
Sprayed three times with 3-3-50 Bordeaux mixture.....	2	59	61.5	8	74	14	4
Control (not dusted or sprayed).....	1	67	55.4	5	45	39	11

#### EXPERIMENTS AT ALBANY, GA.

The trees in the experiments at Albany, Ga., averaged about 30 feet in height and 25 feet in spread of limbs. The trees had been seriously affected with scab for two or three years prior to 1926 and had received no prophylactic treatment until 1926. Therefore, no part of the control that resulted from the treatment given during the summer of 1926 can be attributed to the cumulative effects of protective measures of previous years, as was the case in the orchard at Thomasville. The trees selected were located in an area surrounded by extensive plantings of untreated and scab-infected pecan orchards. Nevertheless, primary leaf infection was almost absent. Careful attention was given to sanitation in the block of trees selected, and this factor alone undoubtedly contributed largely to the lightness of the early leaf infection. The machine used was of the same type and model as the one used in the experiments at Thomasville.

The dusted plot consisted of 26 trees of the Schley variety and 6 trees of Alley. Each tree was given about 3 pounds of dust at each application. The first application was made May 14, followed by 3 to 5 others at intervals ranging from 2 to 4 weeks. The results are shown in Table 3.

TABLE 3.—Results of dusting pecan trees with 20-80 monohydrated copper sulphate and lime mixture for control of pecan scab at Albany, Ga., 1926

Plot No.	Variety and treatment	Average quantity of nuts set per tree	Average loss of nuts per tree from causes other than scab <sup>1</sup>	Average loss of nuts per tree due to scab <sup>2</sup>	Average quantity of nuts harvested per tree
		Pounds	Pounds	Pounds	Pounds
1	Schley, dusted six times.....	24.10	3	0.10	21
2	Schley, dusted five times.....	28.25	4.37	.88	23
3	Schley, dusted four times.....	25.75	2.6	5.15	18
4	Schley, control (not dusted).....	35	2.5	28.9	3.6
5	Alley, dusted five times.....	25.5	4.5	1	20
6	Alley, control (not dusted).....	28	5	20.3	2.7

<sup>1</sup> Black pit, insect injuries, and high winds.<sup>2</sup> Including unmarketable nuts and those which dropped prematurely.

The drop of nuts due to causes other than scab was about half as heavy in the Albany experiments as in those at Thomasville. The trees of the Schley variety which were dusted five and six times each during the season yielded an average of 22 pounds of marketable nuts per tree, and the yield of the Alley trees averaged 20 pounds of marketable nuts. The control trees of the Schley variety sustained an average loss of 28.9 pounds and yielded only 3.6 pounds of small though marketable nuts. The loss from scab on the check Alley trees averaged 20.3 pounds of nuts, and the marketable crop was only 2.7 pounds of small nuts. Plot 3, dusted four times, sustained a 20 per cent loss from scab. An average of 18 pounds per tree of marketable nuts was harvested from this plot, although the nuts graded undersize.

The nuts harvested from plots 1, 2, and 5, as indicated in Table 4, were normal in size and graded satisfactorily. Plots 1 and 2 graded 94 and 98 per cent, respectively, in the No. 1 class and oversize combined. The nuts harvested from plot 3, dusted four times, were undersize, averaged 70 to the pound, and only 86 per cent were classed as No. 1 and larger. The record of the cracking percentage of the nondusted Schley nuts is significant of the degree of faultiness of these nuts. While the nuts in plot 1 analyzed 62 per cent kernel, those harvested from the control trees analyzed only 36 per cent kernel. The kernels of 70 per cent of these nuts (not indicated in Table 4) were found to be defective in some manner, either shriveled or represented by only a dried mass of the kernel tissues. The cracking percentage of the nondusted Alley nuts was but little better.

The crop harvested from the dusted trees of the Alley variety averaged 70 nuts to the pound, tree run (ungraded), which indicates that these nuts were slightly undersize. Sixty-five nuts to the pound is about normal for nuts of this variety grown in the vicinity of Albany, Ga. Since the diameter of the nuts of the Alley variety is greater in proportion to the length than those of the Schley variety, a different system of grading probably would have been preferable. For the sake of uniformity and conciseness, however, the nuts of both varieties were graded by the same method.



TABLE 4.—*Yield, cracking percentage, and grading percentage of nuts harvested from pecan trees included in the dusting experiments at Albany, Ga., 1926*

Plot No.	Variety and treatment	Count of nuts to the pound	Cracking percentage	Grading percentage			
				Over-size	No. 1	No. 2	No. 3
1	Schley, dusted six times.....	54	62	14	80	6	0
2	Schley, dusted five times.....	60	58.8	18	80	2	0
3	Schley, dusted four times.....	70	58.2	5	86	8	1
4	Schley, control (not dusted).....	86	36	0	72	22	6
5	Alley, dusted five times.....	70	52.7	38	60	2	0
6	Alley control (not dusted).....	81	48.2	0	54	30	16.

## METEOROLOGICAL CONDITIONS AFFECTING SCAB INFECTION

Certain meteorological conditions favor the formation of spores and infection by the pecan scab organism, while other conditions have an inhibitory effect. Little or no infection will occur during periods of fair weather with an absence of heavy dew or fog. Showers, even heavy ones, during the forenoon or early afternoon if followed by bright sunshine apparently do not directly favor infection, but probably do so indirectly by favoring the formation of heavy dews or fogs. Precipitation during the evening, even if very light, may furnish excellent conditions for infection, as the leaves and nuts will then be wet for a period of 12 hours or more. The record of the precipitation during a period of a month or for an entire season is not necessarily a good criterion of conditions favoring infection by pecan scab. A record of the number of rainy days during a month or season is a more accurate criterion. Continuous rainy and cloudy weather extending over a period of four hours or more, even though resulting in only a small aggregate precipitation, may furnish excellent conditions for spore germination and infection. The most favorable infection period during the season of 1926 and the one causing the greatest number of infections and resulting in the greatest loss of nuts occurred July 28 and 29. Rain began falling at 5 o'clock a. m. the first day and continued throughout the day and night until 6 a. m. of the following day. Cloudy weather with intermittent showers continued until 5 o'clock of the afternoon of July 29. This meteorological disturbance furnished a 36-hour infection period.

The summer of 1926 was not exceptionally rainy, but compares very favorably with the average, as indicated by Table 5.

TABLE 5.—*Number of days when rain occurred and precipitation during the infection-season months of 1926 at Thomasville, Ga., as compared with a 15-year average (1911 to 1925, inclusive)*

[The number of days includes those with a trace of rain; i. e., less than 0.01 of an inch. The data given in this table, as well as all other climatological data given herein, were furnished by the United States Weather Bureau]

Period covered	April		May		June		July		August	
	Days	Inches	Days	Inches	Days	Inches	Days	Inches	Days	Inches
15-year average.....	8	3.40	12	3.80	16	5.29	20	6.61	17	4.72
Season of 1926.....	9	3.49	7	2.69	17	3.52	19	7.06	22	6.59



From May to August, inclusive, the number of rainy days was the same as in the 15-year average. There were three infection periods during May, the driest month. The first occurred on the 4th, when 0.19 inch fell. The rain began at 7 o'clock p. m. and did not cease until after sunset. The second infection period occurred on the 13th, when rain fell between 5.30 and 6.45 p. m. and was followed by overcast skies until after sunset. The last infection period for the month occurred on the 20th, when 1.47 inches fell during a continuous period between 2 o'clock a. m. and 2 o'clock p. m.

### COST OF DUSTING

Nothing definite can be said about the cost of dusting. The cost is determined by the size of the trees, price of materials, and labor rates. The factors causing variations differ with every grower. The quantity of dust required to furnish an adequate covering at each application ranges from 1 to 2 pounds to the tree for trees just attaining the bearing age, as compared with 8 to 12 pounds for trees of normal size at the age of 20 to 25 years. Two men can easily operate a power-dusting machine. With such a machine running steadily from 50 to 150 trees an hour can be dusted. A machine costs about \$450 f. o. b. shipping point, and the dust 6 to 7 cents or less per pound. It is possible, therefore, for growers to estimate fairly closely what their own dusting operations will cost.

### SUGGESTIONS

As stated previously, this circular gives the results of a single season's success in dusting pecans with monohydrated copper sulphate and lime dust. The writers do not consider that the results of one season's work are sufficiently comprehensive to be used as a basis for dusting schedules. Although the season of 1926 may be considered a normal one from a climatological standpoint, the same schedule which gave success in 1926 may give different results in some other season. Dusting trials over a series of years must be made before definite recommendations can be made. The results of the 1926 experiments are presented at this time so that they may be used as a working basis by growers who wish to test the materials and the method of application herein described.

Sanitation is highly important in a pecan orchard in connection with scab-control operations. The fungus causing the scab disease lives over winter on infected twigs and on infected shucks, leaves, and leaf stems. In order to eliminate as far as possible these sources of infection they should be plowed under previous to the beginning of the spring growth of the trees. The twig stromata are very potent sources of infection and are the most difficult ones to eliminate. To destroy the sporulating powers of the twig stromata, Neal<sup>3</sup> and others, of Mississippi, recommend a spray composed of 1 gallon of commercial lime-sulphur solution to 8 gallons of water, to be applied while the trees are dormant. Summer spraying or dusting will largely prevent twig infections. After the first season's control work,

<sup>3</sup> NEAL, D. C., CHANCE, O. M., BARNHART, R. P., and BYNUM, E. K. SPRAYING EXPERIMENTS FOR PECAN SCAB CONTROL IN MISSISSIPPI IN 1923. Miss. Agr. Expt. Sta. Circ. 53, 4 p. 1924.

therefore, the trees should be practically free from this source of infection.

The 1926 tests indicate that the dust should be applied at night or early in the morning and only while the leaves and nuts are wet with either dew or rain. To effect a more even distribution of the fungicide the dust should be applied from two sides of the trees.

Judging from the results of the Thomasville experiment, an application of dust made while the leaves are wet will afford protection for about 30 days, whereas applications at intervals of about 20 days were required to furnish protection in the Albany experiment. This difference may be attributed to the fact that the Albany trees had received no previous prophylactic treatment, whereas the Thomasville trees had received such treatment for two years. Furthermore, this difference may be due to the location of the Albany trees in an area surrounded by many trees badly infected with the scab disease. These experiments indicate that the dust should be applied at intervals not exceeding three weeks, at least during the first year of treatment. Further experience and trials may prove that applications of dust at longer intervals will give adequate protection, but for the present it is believed that growers should adhere to the three-week schedule. Very finely divided dust composed of 20 per cent monohydrated copper sulphate and 80 per cent high-grade lime, free from calcium carbonate, seems to give good results.

#### DIRECTIONS FOR USING THE COPPER AND LIME DUST

Remove last year's infected nuts and shucks from trees during early winter. Plow the orchard soil prior to April 1, so as to cover deeply all infected nuts, shucks, leaves, and leaf stems.

Make the first application of a 20-80 combination of monohydrated copper sulphate and lime dust immediately after pistillate blossoms have been fertilized. Make additional applications of dust of the same strength at intervals of three to four weeks until about August 1. The number of applications and the length of intervals should be governed by the degree of infection as well as by the extent of the control already obtained.

#### SUMMARY

Pecan scab is an important limiting factor to pecan nut production in southeastern United States.

A mixture of monohydrated copper sulphate and lime dust analyzing approximately 7 per cent metallic copper effectively controlled pecan scab in two localities during the summer of 1926.

In addition to orchard sanitation, four to six applications of a 20-80 mixture of monohydrated copper sulphate and lime dust are tentatively recommended. To those who desire to give dusting a trial it is recommended that the dust be applied while the leaves are wet with either dew or rain.

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